4

N 62 65621

MR No. L5C24

CASE FILE
COPY

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED
April 1945 as
Memorandum Report L5C24

DITCHING TESTS WITH 1/16-SIZE MODELS OF THE ARMY B-17 AIRPLANE IN LANGLEY TANK NO. 2 AND ON AN OUTDOOR CATAPULT

By Robert P. Tarshis and Thelma Stewart

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NACA
WASHINGTON

FILE COPY
To be returned to
the files of the National
Advisory Committee
for Aeronautics
Washington D. C.

NACA WARTIME REPORTS are reprints of papers originally issued to provide rapid distribution of advance research results to an authorized group requiring them for the war effort. They were previously held under a security status but are now unclassified. Some of these reports were not technically edited. All have been reproduced without change in order to expedite general distribution.

MR No. L5C24

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Army Air Forces, Air Technical Service Command

DITCHING TESTS WITH 1/16-SIZE MODELS OF THE ARMY B-17 AIRPLANE IN LANGLEY TANK NO. 2 AND ON AN OUTDOOR CATAPULT

By Robert P. Tarshis and Thelma Stewart

SUMMARY

Tests with dynamically similar models were made to study the behavior of the Army B-17F and B-17G airplanes when ditched and to determine the best way to land them in calm and rough water. The models were ditched in calm water from the tank no. 2 towing carriage and in calm and rough water from an outdoor catapult.

Various landing attitudes, speeds, and conditions of damage were simulated. The model behavior was determined from the study of data obtained by making visual observations, by recording length of run and maximum longitudinal decelerations, and by taking motion pictures of the ditchings.

The tests indicated that, in ditchings in smooth water or parallel to the wave crest, the B-17F and B-17G airplanes should be landed in a tail-down landing attitude of about 7° (three-point landing attitude) and with as low a speed as possible. In this type of ditching, slight skipping or porpoising will probably result. In ditchings in rough, breaking water, the nacelles usually dig in and diving or violent turns may result.

The model tests indicate it is advantageous to jettison the lower gun turret prior to ditching.

INTRODUCTION

Object of tests.- The object of the tests was to determine the best way to land the B-17F and B-17G airplanes in calm and rough water and to determine their probable ditching behavior.

Requested.- Army Air Forces, Materiel Command, March 26, 1943.

Date and place of tests.- The tests were made in Langley tank no. 2 and at an outdoor catapult in 1944.

Full-scale experience.- Reports from the Directorate of Aircraft Safety of six ditchings of the B-17F airplane indicate fairly good ditching characteristics. Out of the 60 crew members involved, no deaths were mentioned as the direct result of the behavior of the airplane in the ditching. Generally, when the crew members were not strapped in or braced, they were thrown around considerably.

In all of these ditchings the airplane was landed with the tail down slightly. Two distinct shocks were usually felt: one when the airplane first touched the water and the other when the nacelles dug in.

PROCEDURE

Two models of the B-17F airplane were used. A chin turret was installed on one of the models to represent the B-17G airplane; this model was tested only in the tank.

Description of Model

Scale.- 1/16 size.

Type of construction.- See reference 1. The skin on the vertical fin was omitted in several tank tests to meet moment-of-inertia requirements. Its ommission had no apparent effect on the results.

Photographs.- Figures 1, 2, and 4 represent the B-17F model; figure 3 represents the B-17G model.

Test Methods and Equipment

The apparatus and test procedure are described in reference 1.

Test Conditions

(All values given refer to full-scale airplane.)

Gross weight.- 57,000 pounds.

Location of center of gravity.- 30 percent of the mean aerodynamic chord; 1.44 inches above the thrust line of the inboard engines.

Attitude of the thrust line.- 10°, 7° (three-point landing attitude), $3\frac{1}{2}^{\circ}$, and 0°.

Flap setting.- Up; semifixed at 45° (full down). In the semifixed condition the flaps were fixed down by friction in such a manner that they were forced up when they struck the water. The use of semifixed flaps was based on the assumption that the flaps of the full-size airplane would fail in striking the water.

Landing speeds.- The range of ground speed covered in the tank tests was from 80 to 160 miles per hour as shown in table II. The airspeeds given below were used at the outdoor catapult. These speeds were for power-off, flaps-down landings as computed from data furnished by Boeing Aircraft Company. It was assumed that the pilot would use the power available to maintain control of the airplane; however, it was not feasible to add power to the models.

Weight (lb)	Attitude thrust line (deg)	Airspeed (mph)
57,000	10	98
57,000	7	110
57,000	$3\frac{1}{2}$	125
57,000	0	145

Condition of simulated damage.- (a) No damage, (B-17F), (fig. 1)

(b) Lower gun turret removed
(1) B-17F (fig. 2)
(2) B-17G (fig. 3)

(c) Bomb-bay doors and lower gun turret removed
(1) B-17F
(2) B-17G

(d) Nose window, camera hatch, main entrance door, and rear gunner's entrance door removed (B-17F)

(e) Nose window, bomb-bay doors, camera hatch, gun turret, rear entrance door, and rear gunner's entrance door removed (B-17F) (fig. 4)

The turret, doors, and hatches were removed to simulate their failure or jettisoning.

Conditions (a), (b), and (c) were tested in the tank only, condition (d) at the outdoor catapult only, and condition (e) at the catapult and the tank.

Condition of seaway.- (a) Calm water

(b) Wave crests parallel to flight path, full-scale height approximately 2 to 9 feet, length approximately 40 to 180 feet

(c) Wave crests perpendicular to flight path, full-scale height approximately 2 to 6 feet, length approximately 40 to 120 feet

RESULTS

The results are presented in tables I and II.

Photographs showing the characteristic behavior of the model are shown in figures 5 through 10.

DISCUSSION

There was little variation between the performance of the B-17F and B-17G models; therefore, they will be discussed as one unless otherwise noted.

The best ditching performance of the model was obtained at the higher attitudes with wings laterally level. In the ditchings, skipping and porpoising usually occurred and maximum longitudinal decelerations of the order of 1.4g to 8g were recorded. At all attitudes and in all water conditions the model made a diving turn when landed with one wing low.

Effect of attitude and speed.- In the ditchings at the lower attitudes, the model skipped or porpoised in the early part of the runs and later in the runs the low-hanging nacelles dug in deeply causing short runs. The nosing-in was aggravated when the lower gun turret remained intact. Increased attitudes and the associated lower speeds resulted in less severe skipping and porpoising and lower decelerations.

Effect of flap setting.- The flaps had little hydrodynamic effect on the ditching characteristics of the model except that the lowered airspeeds due to the use of flaps were advantageous.

Effect of simulated damage.- Tests with the complete model indicated that the lower gun turret caused the model to dive at all attitudes tested in smooth-water tank tests. In the rough-water tests, the turret aggravated the "nosing-in" tendency at the lower attitudes but had little effect on the high-attitude ditching. When the lower gun turret was removed to simulate its failure or jettisoning, slight skipping, porpoising, or smooth runs resulted.

The failure of all doors and hatches did not have any great effect on the ditching performance of the model; however, the failure of the bombardier's window and the bomb-bay doors would hasten flooding of the forward compartment thereby endangering the lives of the crew.

Effect of chin turret.- There was usually little variation between the ditching performance of the models

of the B-17F and B-17G airplanes; however, at the 0° attitude when failure of the lower gun turret and the bomb doors was simulated, the chin turret caused the model of the B-17G airplane to react more violently than the B-17F.

Effect of seaway.- In a swell or when the waves were fairly smooth and appeared in a regular train with the attendant moderate winds, the best ditching was made parallel to the crests of the waves.

When high winds existed, a cross-wind landing resulted in a violent turn; the ditching behavior was usually better when the model landed into the strong winds and across rough breaking waves. The performance was best if the tail contacted on the windward side of a wave. This usually prevented the airplane from being tripped and forced to enter an oncoming wave in a nose-down attitude. (Means of determining wind velocity by observing seaway are discussed in reference 2.)

CONCLUSIONS

It is assumed that the pilot would use sufficient power to maintain control of the airplane. From the results of the tests with the 1/16-size models of the B-17F and B-17G airplanes the following conclusions were drawn:

1. The airplane should be landed in a three-point landing attitude (7°, thrust line).

2. The landing should be made with flaps 45° (full down) and at the slowest possible speed.

3. When ditched onto calm water the airplane will probably skip or porpoise slightly. Maximum longitudinal decelerations of the order of 4g to 6g may be encountered. The length of landing run will probably be about 2 or 3 lengths.

4. In a swell or when moderate wind and waves exist, the airplane should be landed parallel to the crest. It may be advisable to land into the wind and across the waves if a strong wind exists.

5. The landing should be made with the wings laterally level; otherwise a violent turn may result.

Recommended Ditching Modifications

The lower gun turret should be made so that it could be more easily jettisoned.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

REFERENCES

1. Fisher, Lloyd J., and Steiner, Margaret F.: Ditching Tests with a 1/12-Size Model of the Army B-26 Airplane in NACA Tank No. 2 and on an Outdoor Catapult. NACA MR, Aug. 15, 1944.

2. Anon: Aerology for Pilots. McGraw-Hill Book Co., Inc., 1943.

TABLE I

LANDING CONDITIONS AND RESULTS OF DITCHING TESTS AT THE OUTDOOR CATAPULT WITH A 1/16-SIZE MODEL OF THE ARMY B-17F AIRPLANE

[All values are full scale]

Seaway	Attitude of thrust line (deg)	Wave height range (ft)	Wind velocity range (mph)	Performance	
				Condition of damage (d)[1]	Condition of damage (e)[2]
Parallel waves	10	2.5 - 8	30 - 63	Porpoised, then the nacelles dug in at end of run.	Porpoised. Wing low caused the model to turn and the nacelles dug in deeply.
	7	4 - 9	37.2 - 63	Nacelles dug in early in run and brought model to rest quickly.	Smooth-run nacelles dug in at end of run and brought model to rest.
	$3\frac{1}{2}$	2 - 6.5	27.3 - 63	Nacelles dug in very deeply and a pronounced diving tendency was evident.	Nacelles dug in shortly after contact and a diving tendency was evident.
Perpendicular waves	10	2.5 - 4	13.6 - 62.7	Porpoised and nacelles dug in causing heavy spray.	Porpoised. If tail contacted on the crest of a wave, the nose sometimes entered an oncoming wave.
	7	2 - 5	22.4 - 44.8	Nacelles dug in deeply causing heavy spray. If wing was low, a diving turn resulted.	Porpoised slightly or made smooth run.
	$3\frac{1}{2}$	6	56	Made a shallow dive.	Nacelles dug in deeply causing heavy spray.
Smooth water	10	0 - 2	30	Nose dug in early in run.	Heavy spray was raised by the nacelles but the nose was clear during most of the run.
	7	0.5	Calm - 30	Nose and nacelles dug in early in the run.	Nose was clear during part of run. Nacelles dug in at end of run.
	$3\frac{1}{2}$	0.5	Calm - 18	Dived.	Nacelles dug in deeply and brought model to rest.

[1]Simulated failure of nose window, camera hatch, main entrance door, and rear gunner's entrance door.

[2]Simulated failure of nose window, bomb-bay door, camera hatch, lower gun turret, main entrance door, and rear gunner's entrance door.

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

MR No. L5C24

TABLE II

RESULTS OF DITCHING TESTS OF 1/16-SIZE MODELS OF THE ARMY B-17 AIRPLANE IN CALM WATER IN TANK NO. 2

[All values are full scale]

Condition of model	Model	Attitude (thrust line)	10°						7° (three-point attitude)									3½°					0°					
		Speed (mph, full scale)	80		100		120		100			120			140			120		140			140			160		
		See note / Flap setting	Run	Rmk.	Run	Rmk.	Run	Rmk.	Max.	Run	Rmk.	Max.	Run	Rmk.	Max.	Run	Rmk.	Run	Rmk.	Max.	Run	Rmk.	Max.	Run	Rmk.	Max.	Run	Rmk.
a	B-17F	Flaps up			1	d	1	td				8.0	2	d	7.0	1	td											
a	B-17F	Flaps down 45° semifixed			2	d			6.6	1	td	7.0	1	d				1	d	7.4	3	d	7.1	1	d	7.5	2	dt
b	B-17F	↓	2	p	2	s			1.4	4	h	1.6	6	h				5	h	2.9	3	ts	5.1	4	ts	7.4	2	td
b	B-17G									6	h		10	h				6	h					7	s			
c	B-17F									5	h		4	p				3	h					2	s			
c	B-17G									4	h		3	h				3	t.					2	d			
e	B-17F		4	h	3	p				2	s	5.9	1	t				1	ts	7.3	1	t	7.4	1	t	7.0	2	t

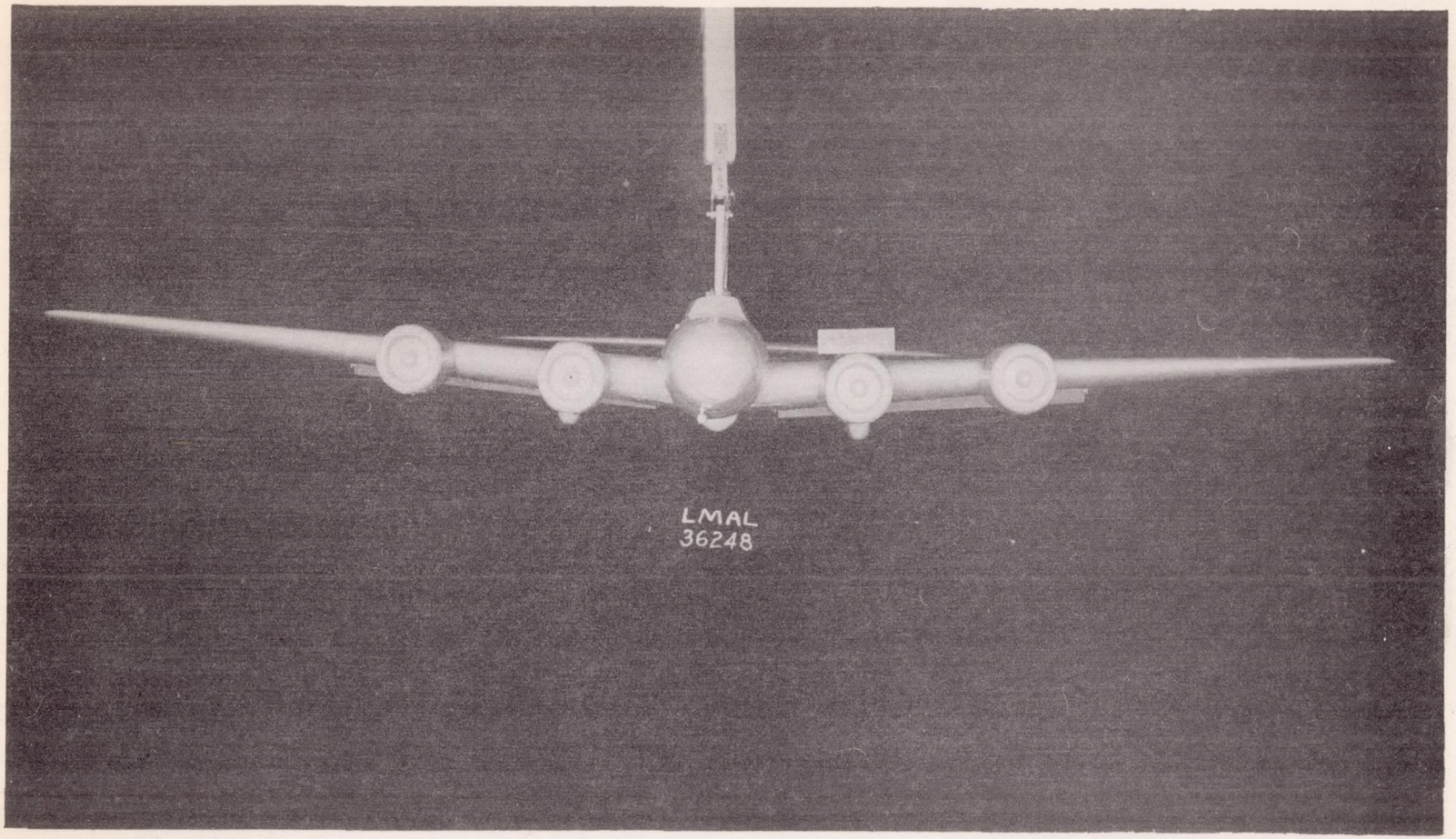
Condition:
a - Complete, simulating no structural damage
b - Lower gun turret removed simulating its failure
c - Simulated failure of lower gun turret and bomb-bay doors
e - Simulated failure of nose window, bomb-bay doors, camera hatch, rear entrance door, lower gun turret, and tail gunner's entrance door

Note:
Max. - Maximum longitudinal decelerations in multiples of the acceleration of gravity
Run - Length of run in multiples of the length of the model
Rmk. - Remarks (see Symbols)

Symbols:
d - dived
t - turned sharply
p - porpoised
s - skipped
h - made a smooth run

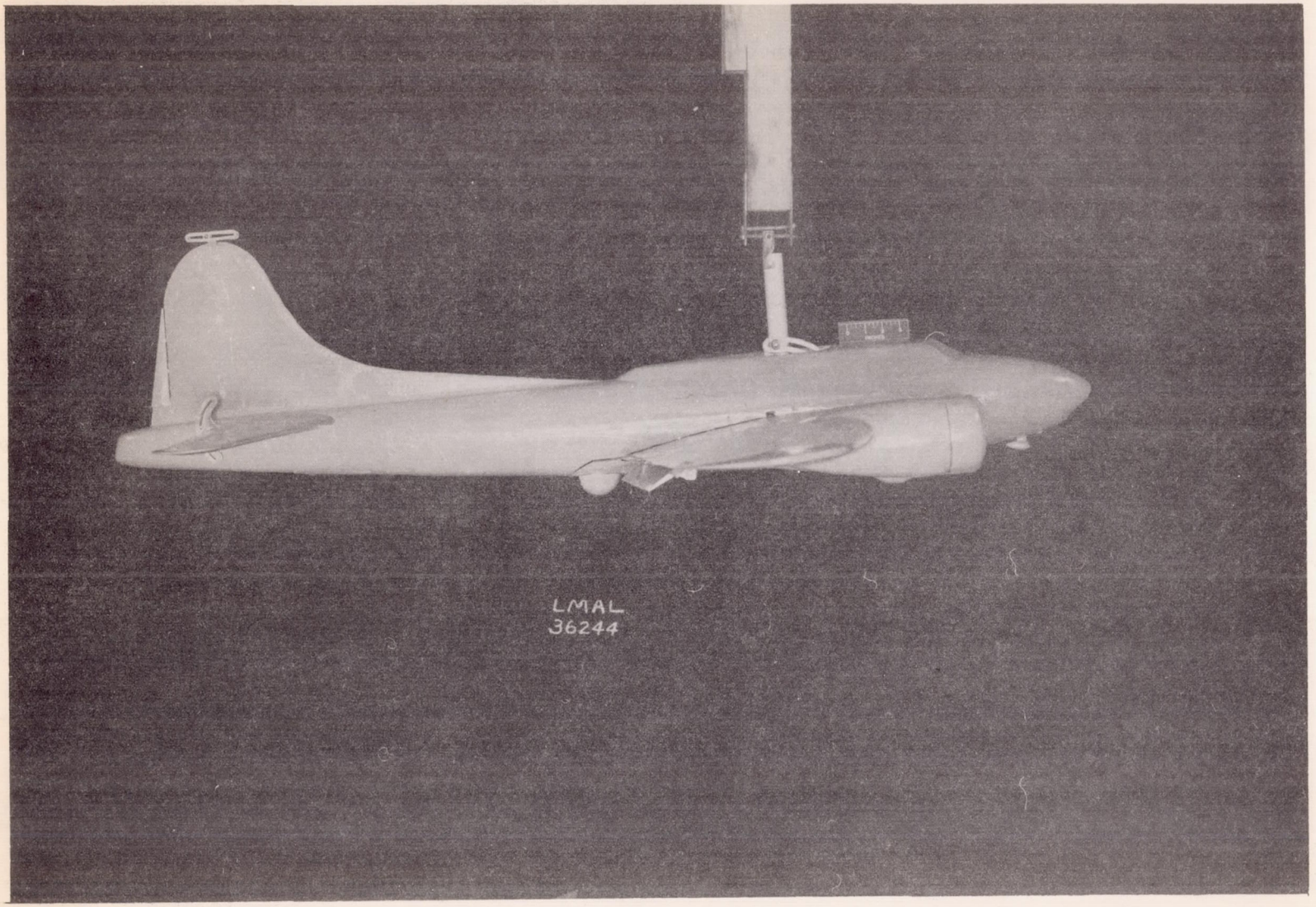
NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

MR No. L5C24



(a) Front view.

Figure 1.- Photograph of a $\frac{1}{16}$-size model of the Army B-17F airplane.



(b) Side view.

Figure 1.- Concluded.

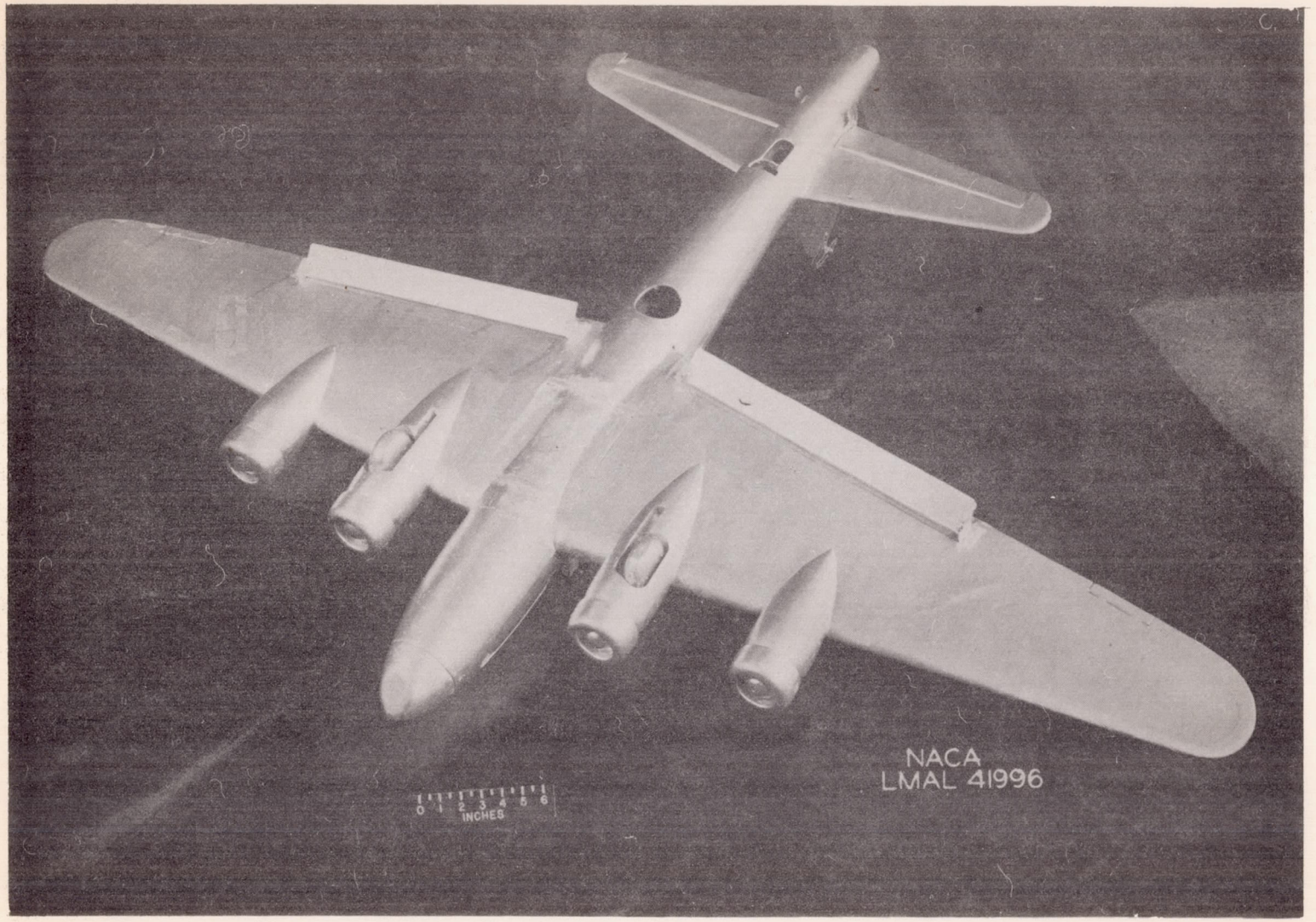


Figure 2.- Photograph of a $\frac{1}{16}$-size model of the Army B-17F airplane with lower gun turret removed.

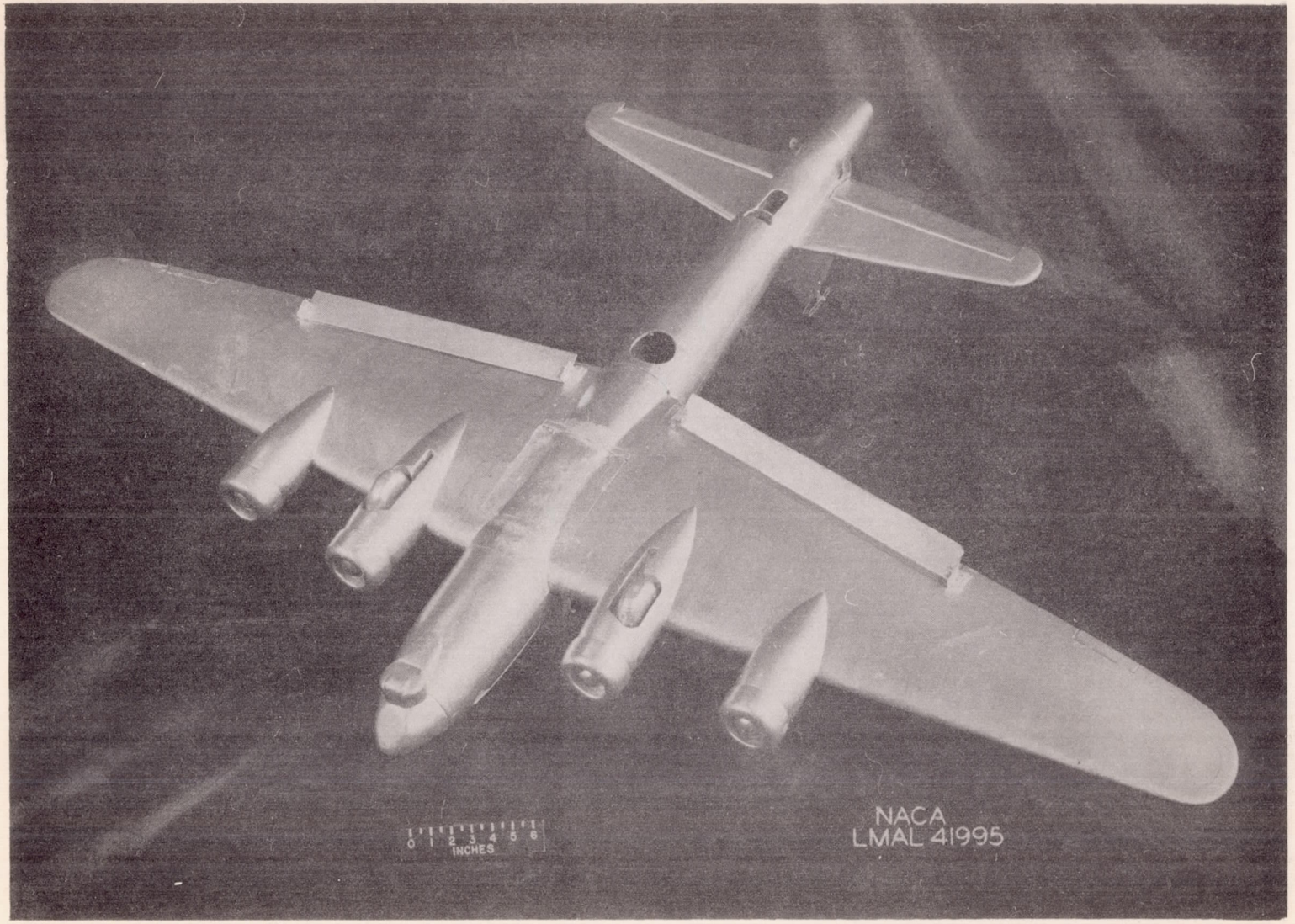
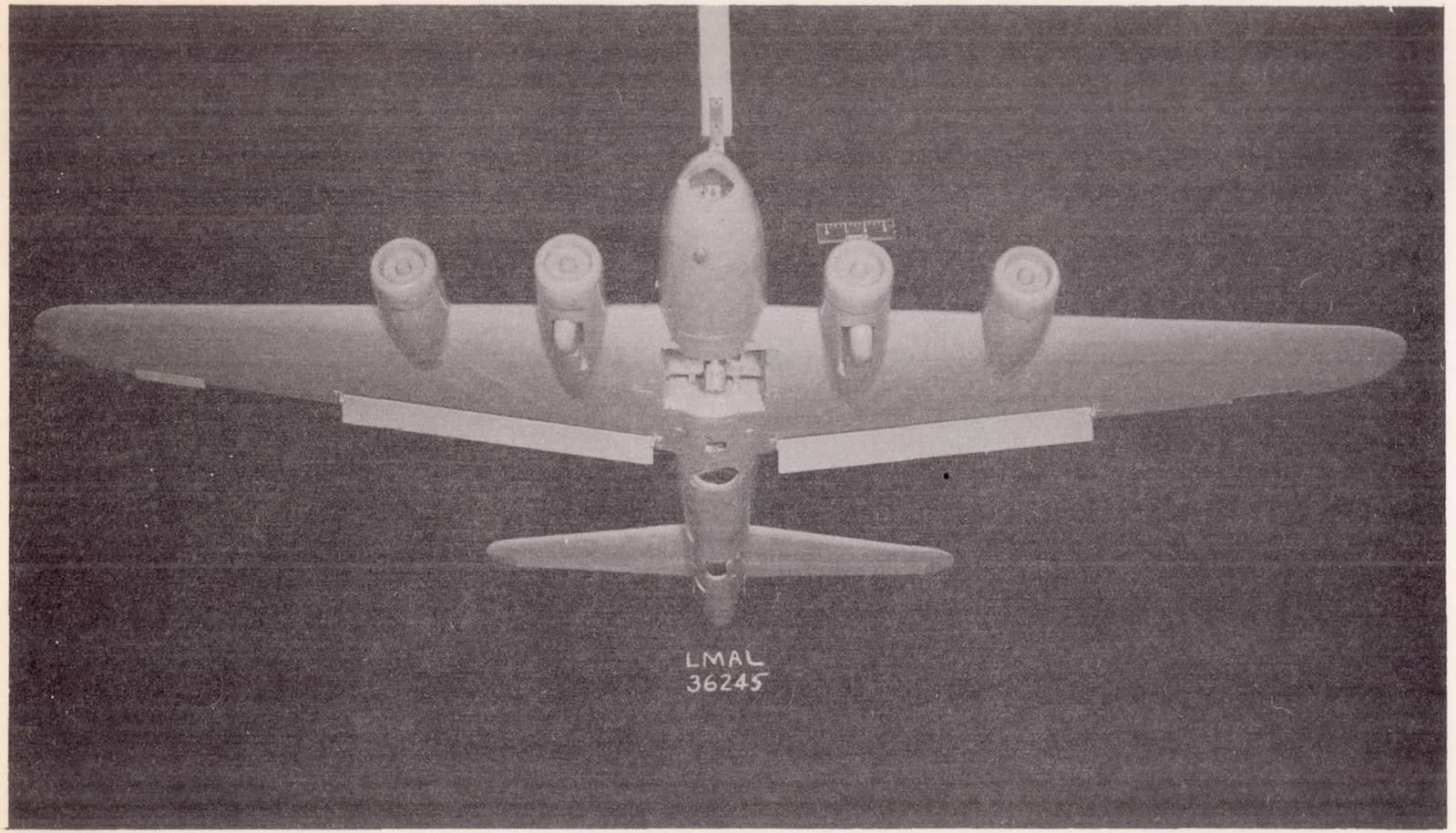
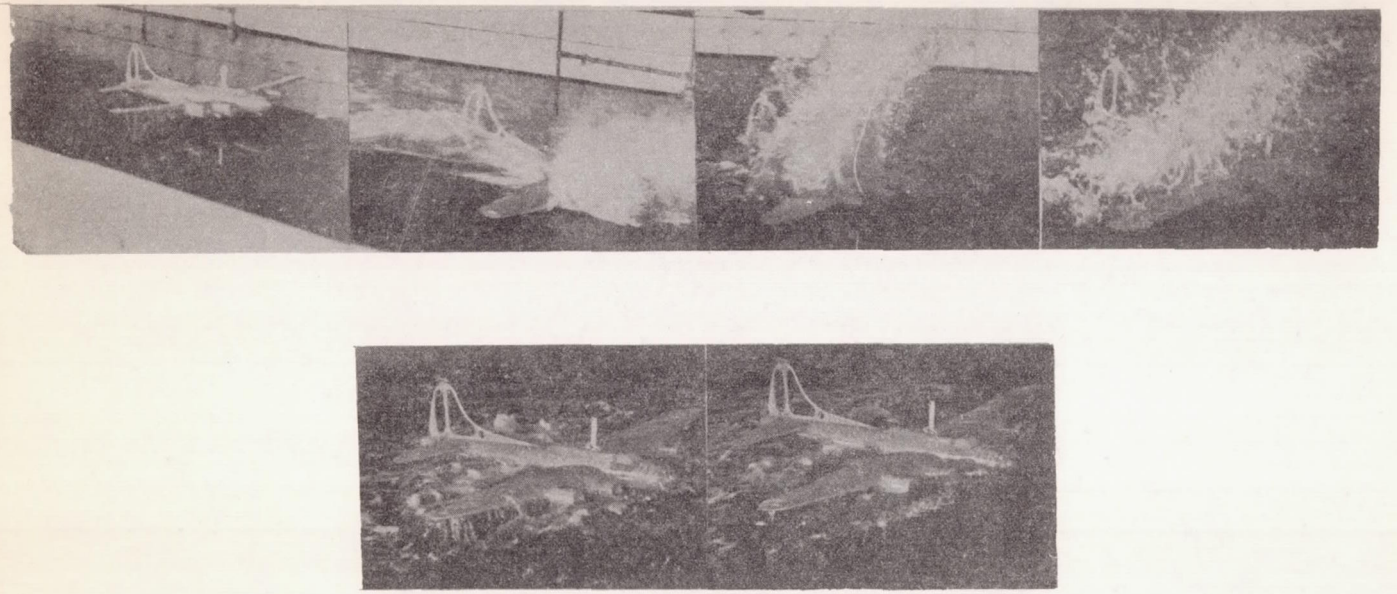


Figure 3.- Photograph of a $\frac{1}{16}$-size model of the Army B-17G airplane with the lower gun turret removed.



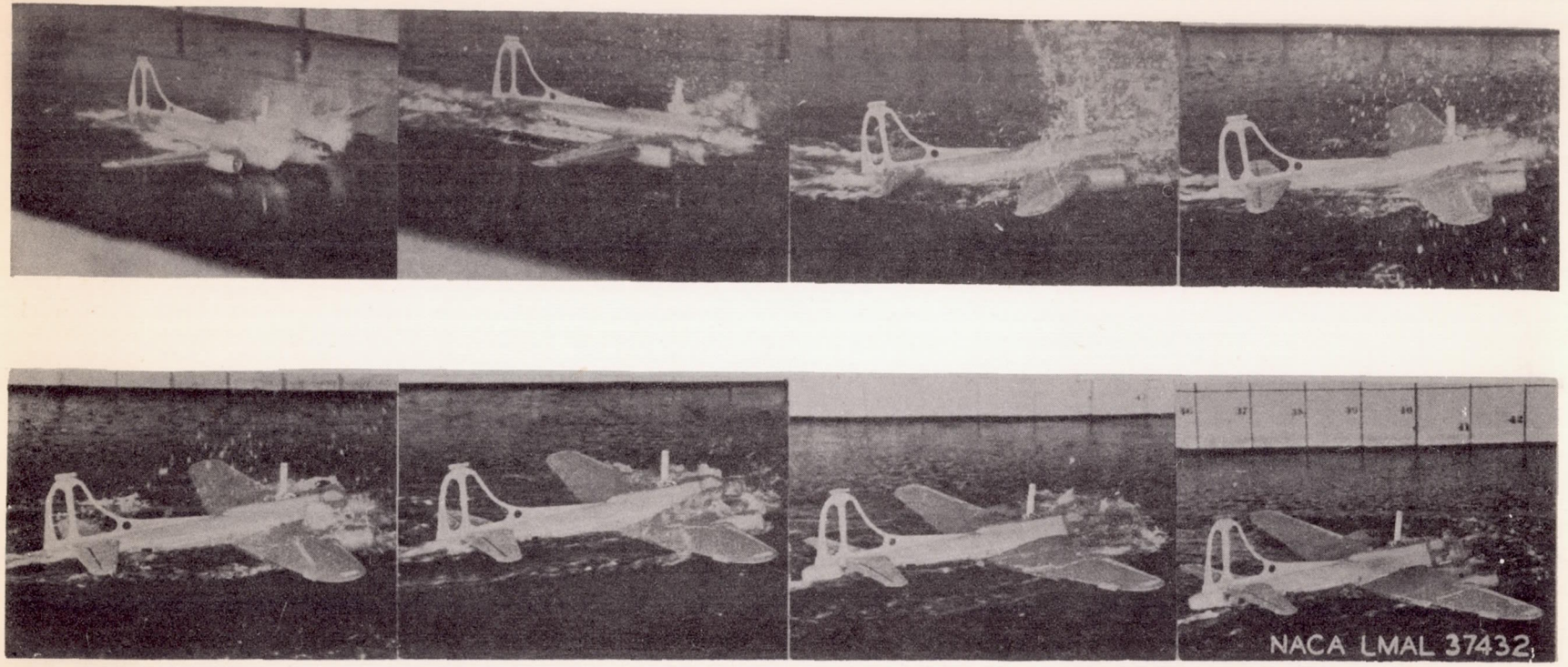
Bottom view.

Figure 4.- Photograph of a $\frac{1}{16}$-size model of the Army B-17F airplane with simulated failure of nose window, bomb-bay doors, camera hatch, lower gun turret, rear entrance door, and tail gunner's entrance door.



(a) Model undamaged

Figure 5.- Photographs of a ditching of a 1/16-size model of the Army B-17F airplane (one second interval full-size). Attitude of thrust line 7°; flaps down 45° semi-fixed; speed, 100 miles per hour, full-scale.



(b) Model with simulated failure of bomb doors, lower gun turret, nose window, camera hatch, main entrance door, and tail gunner's entrance door

Figure 5.- Concluded.

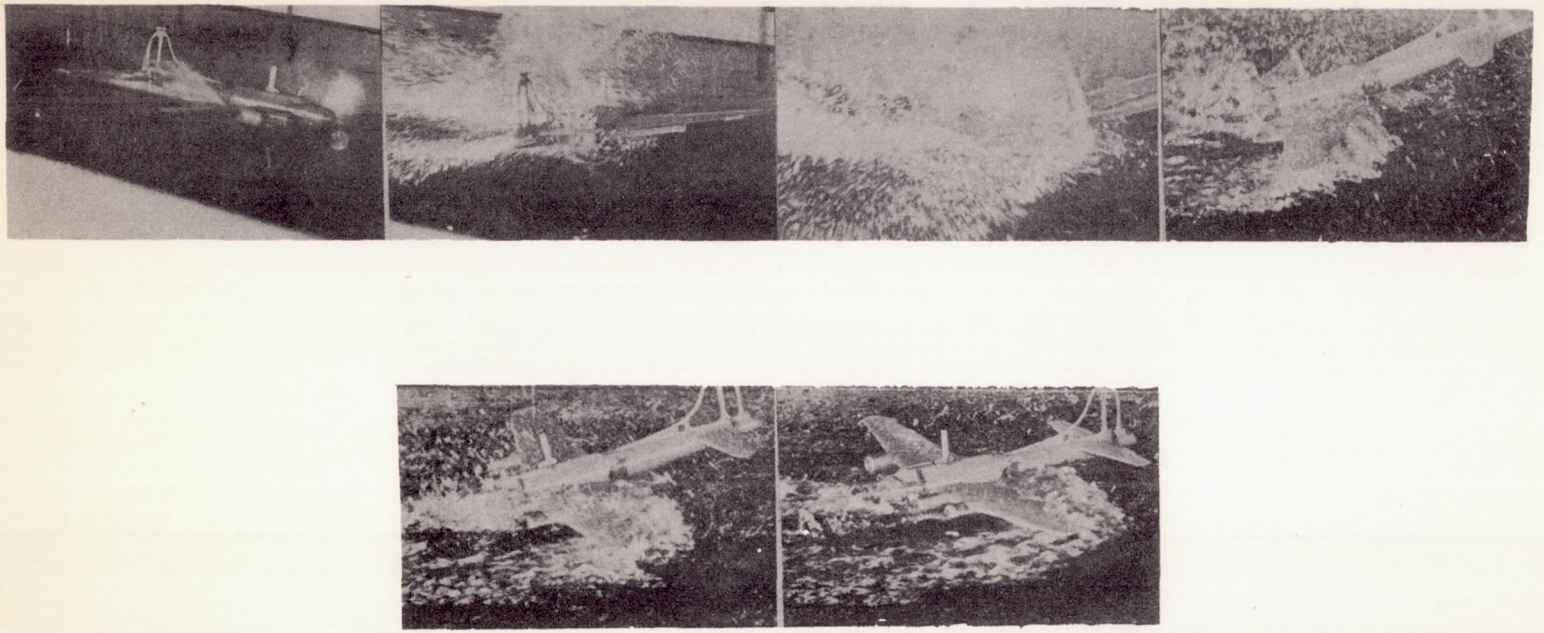
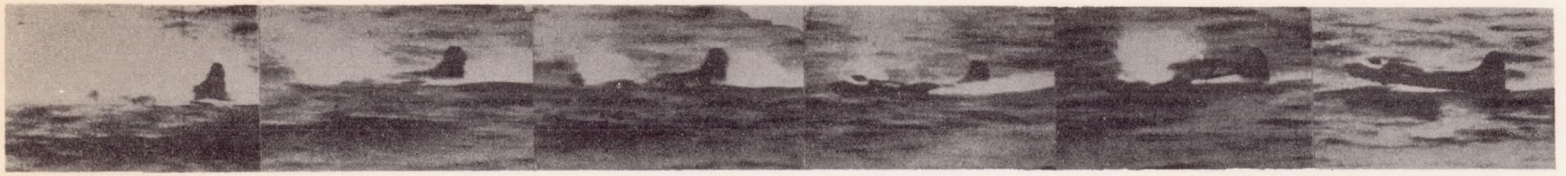


Figure 6.- Photographs of a ditching of a 1/16-size model of the Army B-17F airplane with one wing low (one second intervals full-size). Attitude of thrust line 0°; flaps down 45° semi-fixed; speed, 120 miles per hour; simulated failure of lower gun turret.



3.87 2.91 2.00 1.60 1.10 0

(a) Attitude, thrust line, 10°; air speed, 96 miles per hour.



2.90 2.50 1.35 .90 .60 0

(b) Attitude, thrust line, 7°; air speed, 110 miles per hour.

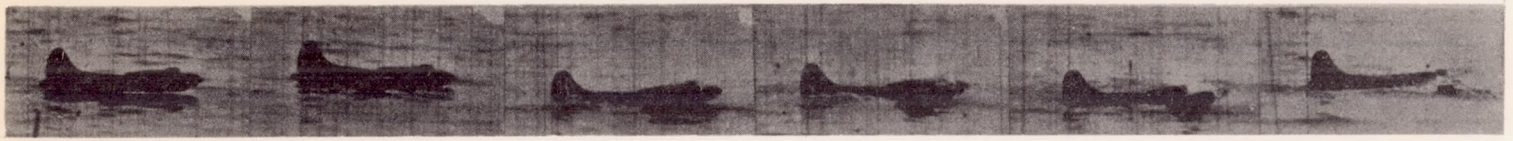


2.70 2.56 1.60 .85 .30 0

(c) Attitude, thrust line, $3\frac{1}{2}^{\circ}$; air speed, 125 miles per hour.

Figure 7.- Photographs of three ditchings of a $\frac{1}{16}$-size model of the Army B-17F airplane parallel to short, rough waves.
Simulated damage of camera hatch, nose window, main entrance door and rear gunner's entrance door.
Full-Scale time in seconds listed under pictures.

MR No. L5C24



0 .43 1.55 2.68 3.80 5.67

(a) Attitude, (thrust line) 7°; parallel waves, height, 18 inches.



0 .60 .90 1.68 2.06 3.20

(b) Attitude (thrust line), $3\frac{1}{2}^{\circ}$; parallel ripples (superimposed on long swell perpendicular to ripples)

Figure 8.- Photographs of two ditchings of a $\frac{1}{16}$-size model of the Army B-17F airplane with simulated damage of bomb doors, lower gun turret, nose window, camera hatch, main entrance door, and rear gunner's entrance door. Full-scale time in seconds listed under pictures.

MR No. L5C24

L -.621

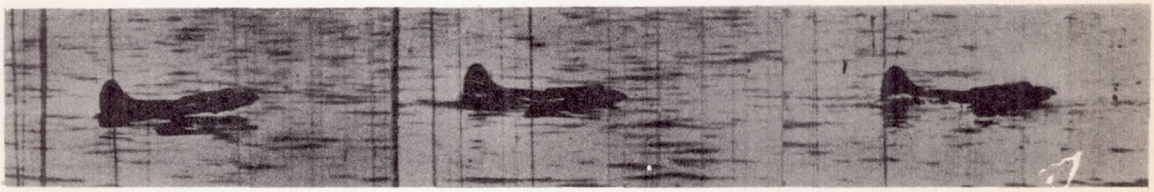


0 .40 .70

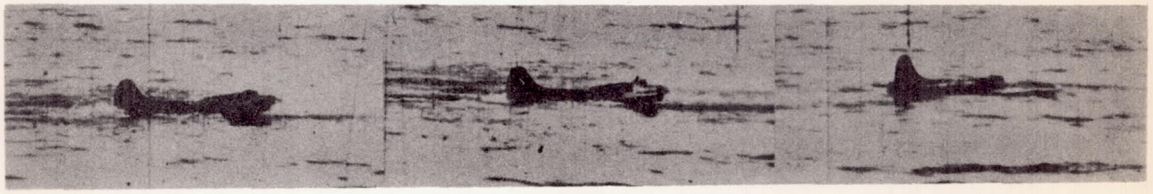


1.05 1.85 2.75

(a) Attitude $3\frac{1}{2}^{\circ}$; air speed 125 miles per hour, gun turret remains intact; swell-height 84 inches; wind velocity, 40 miles per hour 0° to path.



0 .44 1.80



3.70 4.80 6.95

(b) Attitude 10°, air speed 96 miles per hour, gun turret considered torn off at initial contact, parallel waves height 24 inches; wind velocity, 20 miles per hour, 90° to path.

Figure 9.- Photographs showing two extreme behaviors that might be experienced by a B-17F airplane in a ditching. Full-scale time in seconds listed under each picture.



2.80 1.80 1.30 .80 .25 0

(a) Attitude (thrust line) 7°, air speed 110 miles per hour.



4.20 2.38 1.30 .80 .48 0

(b) Attitude (thrust line) $3\frac{1}{2}^{\circ}$, air speed, 125 miles per hour.

Figure 10.- Photographs of a $\frac{1}{16}$-size model of the Army B-17 airplane ditched with one wing low. Simulated damage of bomb doors, lower gun turret, nose window, camera hatch, main entrance door, and rear gunner's entrance door. Full-scale time in seconds listed under pictures.